

Variation of Different Fatty Acids in Mutants in Comparison with Natural Soybean Varieties

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Summary

Fatty acid mutants were developed from the M_3 progeny of X-ray irradiated seeds of soybean [*Glycine max* (L.) Merr. cv. Bay]. Considerable genetic variability was observed in the contents of fatty acids such as palmitic, stearic, oleic, linoleic and linolenic, in the oil of Bay-derived mutants compared with those in the oil of the natural varieties. Mutants developed by X-ray irradiation could be used as new genetic resource in the breeding program for the improvement of soybean oil quality.

Key words: *Glycine max*, induced mutation, fatty acid mutants, natural varieties

Introduction

Mutation breeding has been utilized successfully to induce genetic variability in the fatty acid composition of oil crops in order to improve the oil quality. As a result, fatty acid mutants in rape¹⁾, flax²⁾ and sunflower³⁾ were developed. In soybean, various types of mutants for palmitic⁴⁻⁶⁾, stearic^{5,7)} and linolenic acid content^{8,9)} have been successfully screened by using different mutagens. In a series of study, different mutants for low and high palmitic¹⁰⁾, high stearic¹¹⁾, high oleic¹²⁾, high linolenic¹³⁾ and low linolenic acid content¹⁴⁾ have been screened in our laboratory by using X-ray irradiation. Most of the described mutants were recessive and the mutation frequency was relatively low.

The purposes of the study reported here were: 1) to evaluate the effectiveness of induced mutation for genetic variation in the fatty acid composition and 2) to compare the changes in the fatty acid composition of mutants with natural variability in soybean.

Materials and Methods

Dry seeds of the soybean variety Bay were irradiated with 21.4 kR X-rays and sown in 1986. The M_2 seeds from the M_1 plants were sown in different years for the selection of mutants in relation to the fatty acid composition in the oil. In total there were 12,266 M_2 plants of which 2,000 plants were analyzed for fatty acid composition in 1987, 2,006 in 1988, 3,000 in 1989, 2,747 in 1990 and 2,513 plants in 1991. M_2 plants with altered fatty acid composition as compared with Bay variety were screened and were confirmed as the mutants by observing the similar fatty acid composition in respective M_3 generations.

Forty six different fatty acid mutants were developed from these selection studies. The mutants, Bay and 99 soybean varieties which were collected from different areas of Japan and Korea, were planted in rows in the field of Saga University in 1992. At maturity, 40 seeds from five plants of each mutant, Bay and other varieties were crushed and the oil was extracted with ethylether. Standard analytical methods for methylesterification and separation of fatty acids by gas chromatography, were applied as described by Takagi *et al.*¹³⁾.

Results and Discussion

Treatment with X-ray irradiation considerably increased the variability of the fatty acid composition of oil in the Bay variety as compared with the natural soybean varieties. The frequency distribution of fatty acids in Bay-derived 46 mutant lines compared with 99 natural varieties is indicated in Fig. 1. The palmitic acid content of the mutants ranged from 6.3 to 16.7%, compared with 10.0 to 15.5% in the natural varieties (Table 1). The low and high contents of palmitic acid in the mutants varied remarkably and exceeded the range of natural varieties. Stearic acid content of the mutants varied from 2.9 to 16.1%, compared with 1.6 to 4.1% in the natural varieties. Although the low content of this fatty acid in the mutants did not vary appreciably, occasionally four-fold increase in the content was observed in some mutants compared with that of the natural varieties. Variation in the palmitic and stearic acid contents in the mutants in this study exceeded those reported by other investigators in which palmitic acid contents ranged from 10.0 to 12.0%¹⁵⁾, and the stearic acid ranged from 2.2 to 7.2 %¹⁶⁾. The range of the oleic acid content in the mutants varied from 17.5 to 48.2%, compared with 14.2 to 44.3% in the natural varieties. The

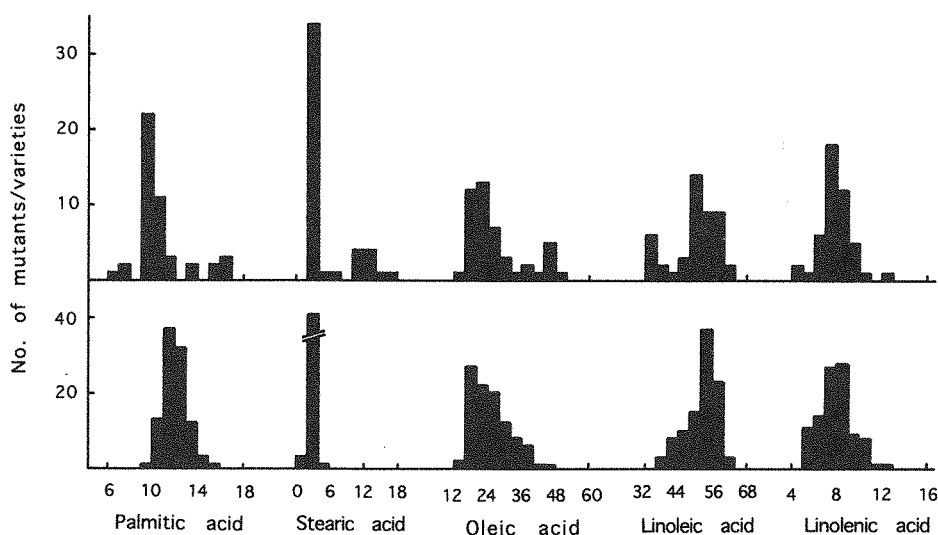


Fig. 1. Frequency distribution of different fatty acids in mutants (upper) and varieties (lower) of soybean.

linoleic acid content varied from 32.2 to 60.5% in the mutants compared with 36.6 to 61.1% in the natural varieties. The distribution of the oleic and linoleic acid contents in the Bay-derived mutants covered the range of both fatty acids in the natural varieties. The linolenic acid content in the mutants varied from 4.6 to 12.6% compared with 5.2 to 12.6% in the natural varieties. Thus, it was possible to reduce the content of linolenic acid in a mutant compared with that of the natural varieties. It was reported that soybean oil with reduced contents of linolenic acid displayed a greater odor and flavor stability¹⁷⁾.

Table 2 shows the fatty acid composition of some distinctive mutants, and Bay from which the mutants were developed. Lowest and highest values of palmitic acid were observed in mutants J3 and J10 with 6.3 and 16.7%, respectively, as compared with 11.6% for the Bay variety. Minimum and maximum contents of stearic acid in the mutants KK2 and M25 were 6.1 and 16.1%, respectively, whereas that of Bay variety it was 2.9%. The contents of the oleic acid in the mutants M6, M11, M23 and M21 were 17.5, 35.9, 40.0 and 48.2%, respectively, while it was 23.3% in the Bay. The linolenic acid contents in M-5, KL-8 and B739 were 4.6, 6.6 and 12.6% respectively, compared with 8.2% in the Bay.

Table 1. Mean and range of fatty acid composition (% of total oil) in different mutants and natural varieties of soybean.

	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
Mutants					
Mean	10.6	5.2	26.5	49.8	7.9
Range	6.3~16.7	2.9~16.1	17.5~48.2	32.2~60.5	4.6~12.6
Varieties					
Mean	12.1	2.9	25.1	51.9	8.0
Range	10.0~15.5	1.6~4.1	14.2~44.3	36.6~61.1	5.2~12.6

Table 2. Some distinctive fatty acid mutants developed by induced mutation.

Mutant line	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
J3	6.3	2.9	25.9	56.9	8.1
J10	16.7	3.2	22.2	49.4	8.5
KK2	11.1	6.1	19.3	54.5	8.9
M25	9.1	16.1	16.5	50.2	8.1
M6	9.1	3.2	17.5	60.5	9.7
M11	9.5	2.6	35.9	44.9	7.4
M23	10.4	2.9	40.0	38.8	7.9
M21	9.5	2.7	48.2	32.2	7.4
M-5	11.6	2.9	24.0	56.8	4.6
KL-8	8.8	3.1	20.8	60.7	6.6
B739	9.9	10.3	24.1	43.1	12.6
Bay	11.6	2.9	23.3	54.1	8.2
	±0.08	±0.02	±0.27	±0.19	±0.06

It is suggested that the use of X-ray irradiation may be advantageous for the improvement of the oil composition in soybean. Soybean seeds treated with X-ray irradiation, followed by selection in M_3 generations, displayed changes in the fatty acid composition of oil. It is noted that every mutant had all the good agronomical characteristics, such as, plant type, flowering and maturity period, and seed size as in Bay variety during the M_3 as well as next generations of these mutants and Bay variety grown together under the same environmental conditions. However, the oil of several mutants may be used for different purposes compared with the oil of natural soybean varieties as the use of soybean oil depends on its fatty acid composition^{5,6)}.

The genetic variation observed in the fatty acid composition of the oil of natural soybean varieties was limited. Therefore, X-ray irradiation could be applied to increase the variability in the populations and produce new genetic combinations which could be used in breeding programs for the improvement of soybean oil quality. The results obtained in this study were relatively successful, considering the fact that 12,266 M_2 plants were involved. Through irradiation and observation of larger populations, the probability of obtaining mutants with an improved fatty acid composition of oil could be greatly increased for the use of human consumption, livestock feed and industrial or any other specific applications.

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ダイズ諸種の脂肪酸突然変異体と品種の脂肪酸組成の比較

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摘 要

ダイズ [*Glycine max* (L.) Merr. cv. Bay] にX線を照射したM₃世代で、脂肪酸組成を異にした諸種の突然変異体を得た。Bayから得られた突然変異体について、パルミチン酸、ステアリン酸、オレイン酸、リノール酸、リノレン酸の遺伝的変異を品種の脂肪酸組成と比較したところ、X線照射から得られた突然変異体は、ダイズ油の品質を改良する育種のための新しい遺伝的資源となることが分った。